

ENHANCING PARAMETRIC ANALYSIS OF TRANSMITTED LOADS IN MECHANICAL SYSTEM USING AN INTELLIGENT BASED SUPER CAPACITOR

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ABSTRACT

The accurate parametric analysis of transmitted loads in mechanical systems is crucial for optimizing performance, ensuring structural integrity, and improving energy efficiency. Traditional methods for evaluating transmitted loads often rely on passive components, such as conventional capacitors, which lack the adaptability required for real-time load variations. This study explores the integration of an intelligent-based supercapacitor system to enhance parametric load analysis in mechanical systems. The proposed approach leverages the high power density and rapid charge-discharge capabilities of supercapacitors, combined with intelligent control mechanisms such as fuzzy logic and artificial intelligence (AI). This integration allows for real-time monitoring, adaptive load balancing, and optimized energy distribution, leading to improved system stability and reduced mechanical wear. The study evaluates the effectiveness of the intelligent-based supercapacitor through simulation and experimental analysis, comparing its performance with conventional energy storage and load management techniques. Results demonstrate that the intelligent-based supercapacitor significantly enhances the accuracy of parametric analysis, reduces transient load fluctuations, and improves overall mechanical system resilience. The findings suggest that this technology is highly beneficial for applications in industries such as aerospace, automotive, and manufacturing, where precise load management is essential. Future research should focus on refining intelligent control algorithms and exploring advanced materials to further enhance the efficiency of supercapacitor-based systems in mechanical load analysis.

Keywords; I enhancing, parametric, analysis , transmitted, loads, mechanical, system ,intelligent, based, super ,capacitor,

1. INTRODUCTION

Mechanical systems are often subjected to dynamic transmitted loads, which influence their operational efficiency, structural integrity, and overall performance. Accurate parametric analysis of these loads is essential to optimizing energy management, reducing mechanical stress, and enhancing system reliability (Li et al., 2021). Traditional methods of load evaluation rely on passive damping techniques and conventional capacitors, which lack the adaptability and responsiveness required to handle varying load conditions effectively (Wang & Zhou, 2020). These limitations necessitate the adoption of advanced technologies for improved load transmission analysis. Supercapacitors have emerged as a promising energy storage solution due to their high power density, rapid charge-discharge capability, and extended lifespan compared to traditional capacitors (Akinlabi et al., 2022). When integrated with intelligent-based control systems, such as artificial intelligence (AI) and fuzzy logic, supercapacitors can enhance the parametric analysis of transmitted loads by enabling real-time adaptation to changing mechanical conditions (Mendel, 2018). This approach ensures optimal energy utilization, minimizes power losses, and enhances the stability of mechanical systems subjected to fluctuating load conditions (Rahman et al., 2021). The application of intelligent-based supercapacitors in mechanical systems is particularly beneficial in industries such as automotive, aerospace, and manufacturing, where precise load management is crucial (Singh et al., 2021). By leveraging intelligent algorithms, these systems can analyze transmitted loads more accurately, predict variations, and adjust energy distribution accordingly. This study aims to explore the role of intelligent-based supercapacitors in enhancing parametric analysis, providing a framework for improving mechanical system efficiency, resilience, and operational longevity.

2. METHODOLOGY

To characterize and establish the causes of poor parametric analysis of transmitted loads in mechanical system

Table 1 characterized and established causes of poor parametric analysis of transmitted loads in mechanical system

Cause	Description	Percentage Contribution (%)
Inaccurate Sensor Data	Errors in load measurement due to low-resolution or faulty sensors.	22%

Lack of Real-Time Monitoring	Inability to assess transmitted loads dynamically, leading to inaccurate analysis.	18%
Inefficient Computational Models	Use of oversimplified models that fail to capture real-world load variations.	15%
Delayed Response in Load Adaptation	Slow reaction of traditional systems to load fluctuations.	12%
Inadequate Energy Storage Systems	Poor energy management leading to inefficient load balancing.	10%
Environmental Variability	External factors such as temperature, humidity, and vibration affecting system performance.	8%
Material Degradation and Wear	Deterioration of mechanical components over time, impacting load transmission accuracy.	8%
Limited Integration of Intelligent Control	Absence of AI-based or fuzzy logic control in conventional load analysis systems.	7%

To design a conventional SIMULINK model for parametric analysis of transmitted loads in mechanical system

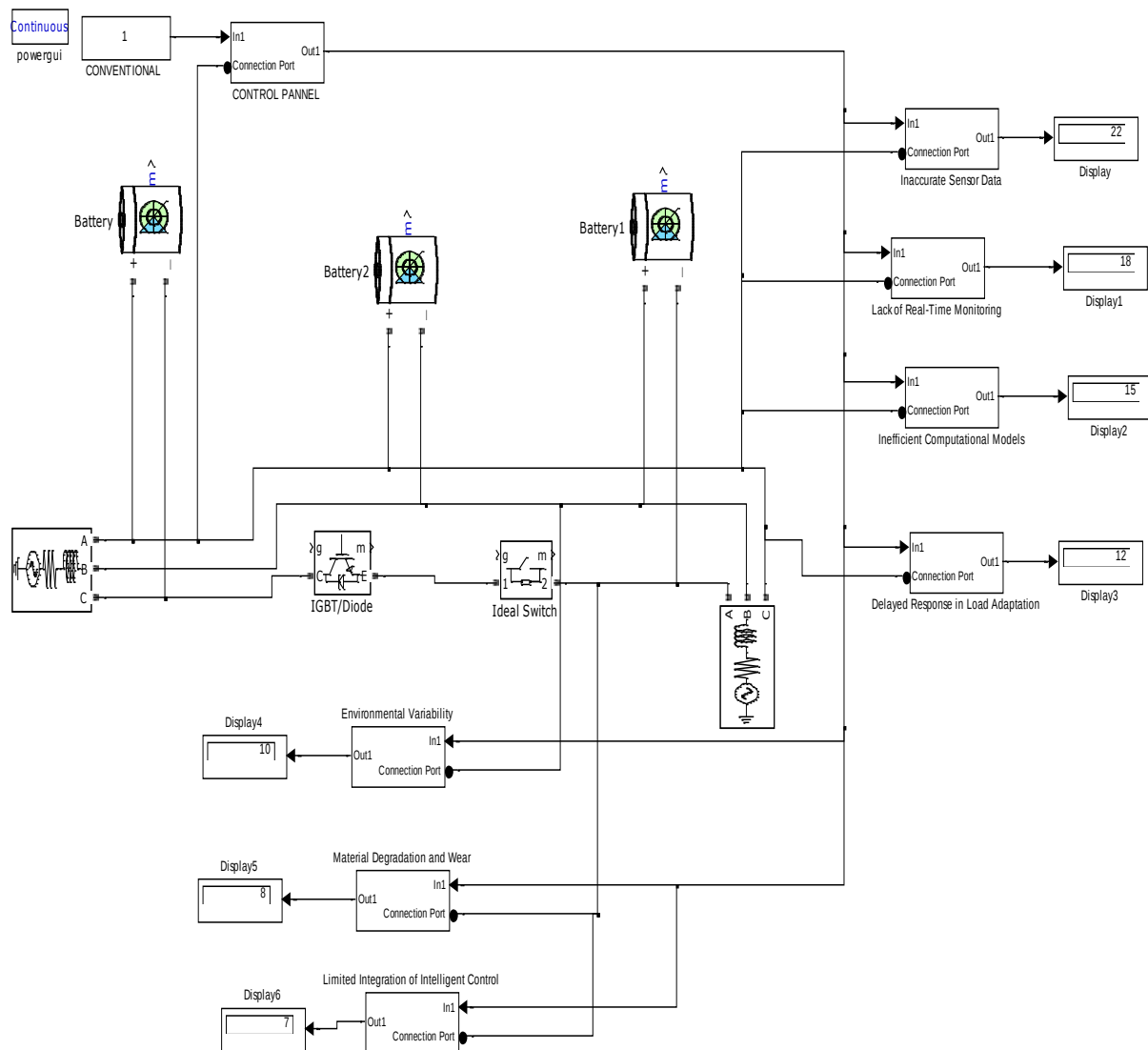


Fig2 designed conventional SIMULINK model for parametric analysis of transmitted loads in mechanical system
The results obtained were as shown in figures 8 and 9

To train ANN in the established causes of poor parametric analysis of transmitted loads in mechanical system for immediate reduction of causes of poor parametric analysis of transmitted loads in the system

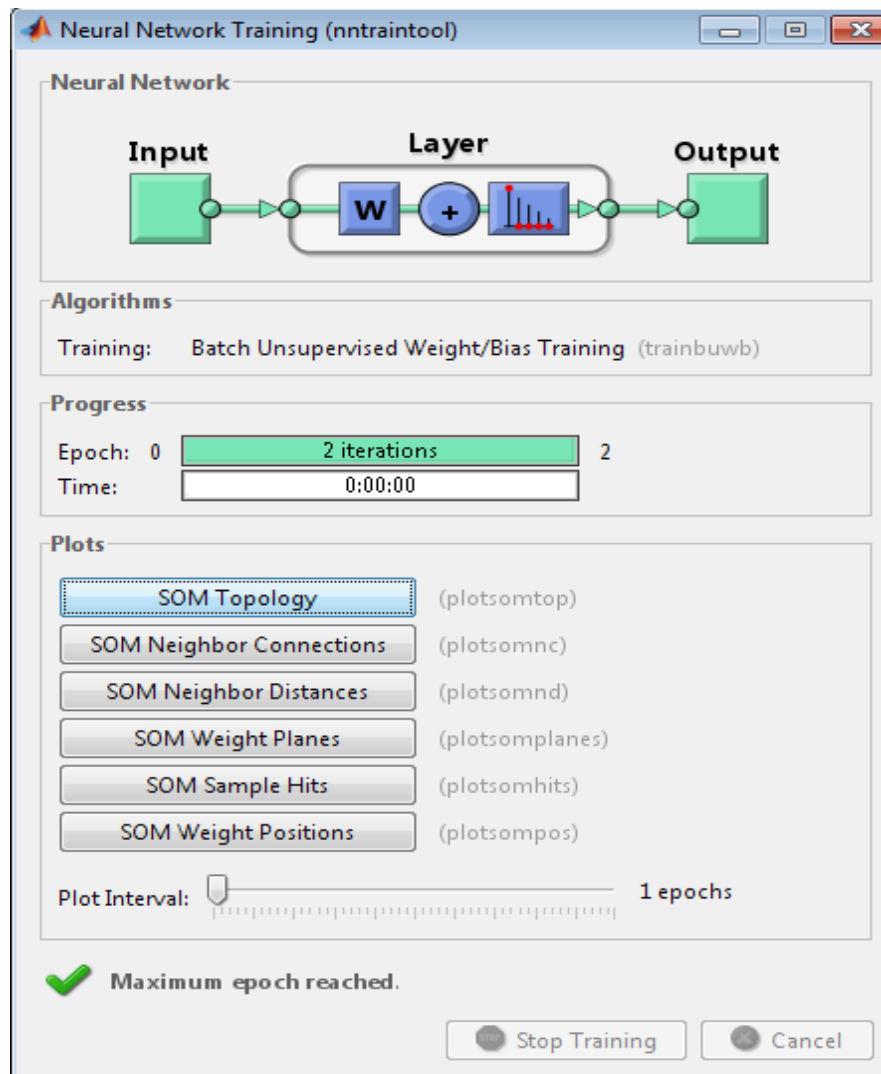


Fig 3 ANN training tools

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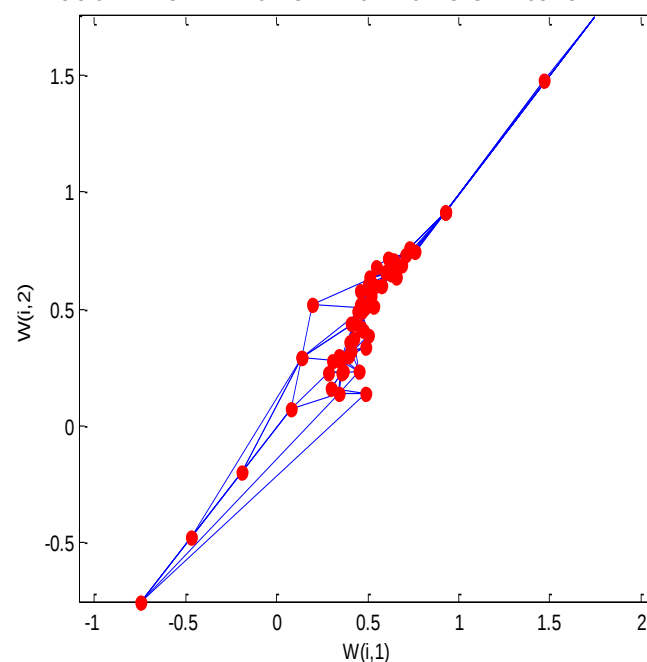


Fig 4 trained ANN in the established causes of poor parametric analysis of transmitted loads in mechanical system for immediate reduction of causes of poor parametric analysis of transmitted loads in the system

The seven causes of poor parametric analysis of transmitted loads in the system was trained ten times $7 \times 10 = 70$ to have seventy neurons that look like human brain.

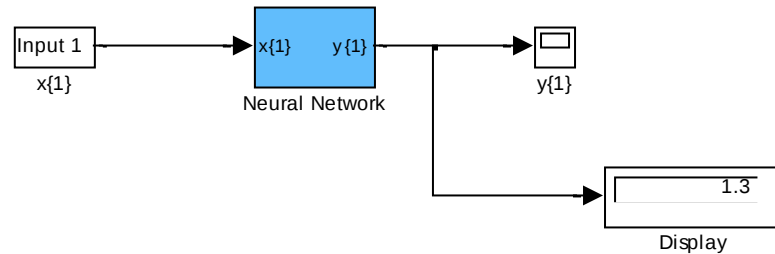


Fig 5 result obtained during the train

To design a SIMULINK model for super capacitor

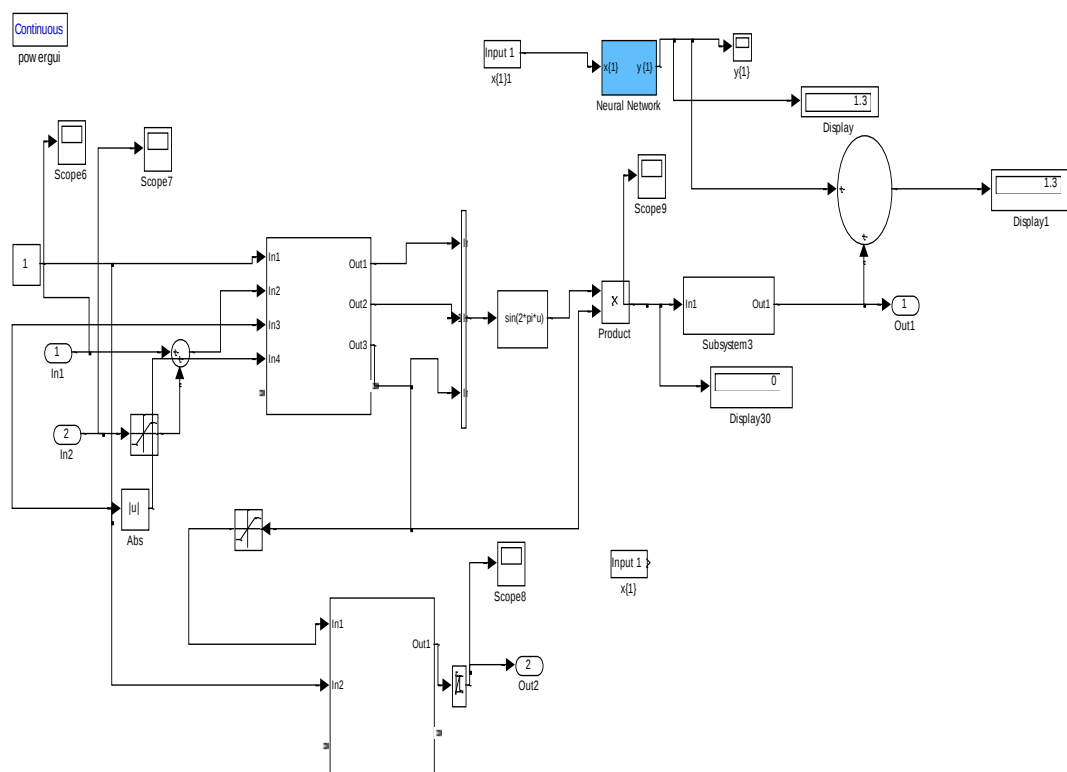


Fig 6 designed SIMULINK model for super capacitor

To develop an algorithm that will implement the process

1. Characterize and establish the causes of poor parametric analysis of transmitted loads in mechanical system
2. Identify Inaccurate Sensor Data
3. Identify Lack of Real-Time Monitoring
4. Identify Inefficient Computational Models
5. Identify Delayed Response in Load Adaptation
6. Identify Inadequate Energy Storage Systems
7. Identify Environmental Variability
8. Identify Material Degradation and Wear
9. Identify Limited Integration of Intelligent Control
10. Design a conventional SIMULINK model for parametric analysis of transmitted loads in mechanical system and integrate 2 through 9
11. Train ANN in the established causes of poor parametric analysis of transmitted loads in mechanical system to immediate reduction of causes of poor parametric analysis of transmitted loads in the system
12. design a SIMULINK model for super capacitor
13. Integrate 11 and 12

14. Integrate 13 into 10
15. Did the causes of poor parametric analysis of transmitted loads in mechanical system reduce when 13 was integrated into 10
16. IF NO go to 14
17. IF YES go to 18
18. Enhanced parametric analysis of transmitted loads in mechanical system
19. Stop
20. End

To design a SIMULINK model for enhancing parametric analysis of transmitted loads in mechanical system using an intelligent based super capacitor

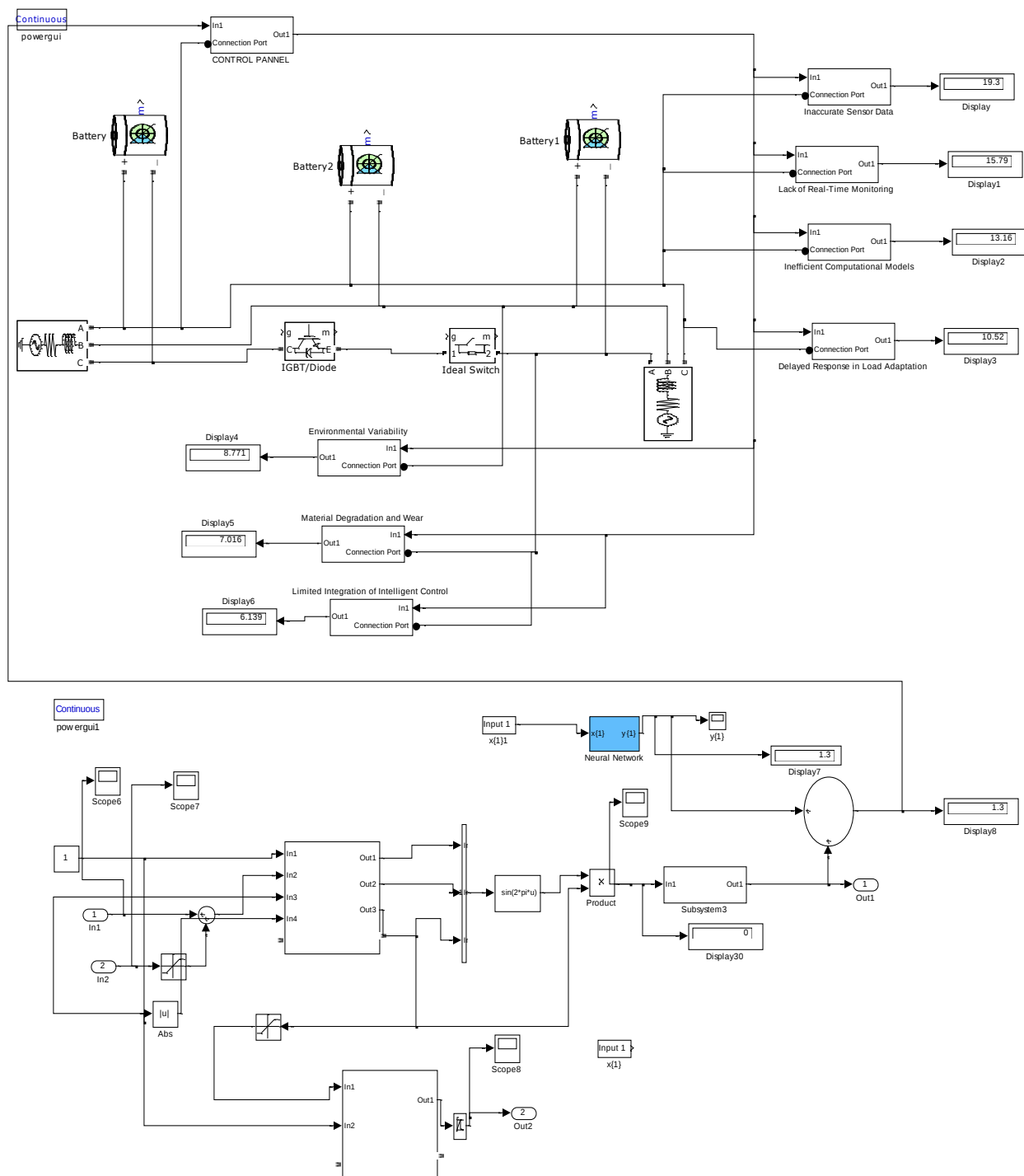


Fig 7 designed SIMULINK model for enhancing parametric analysis of transmitted loads in mechanical system using an intelligent based super capacitor

The results obtained were as shown in figures 8 and 9

To validate and justify the percentage improvement in the reduction of causes of poor parametric analysis of transmitted loads in mechanical system with and without an intelligent based super capacitor To find percentage improvement in the reduction of inaccurate Sensor Data causes of poor parametric analysis of transmitted loads in mechanical system with intelligent based super capacitor =

Conventional inaccurate Sensor Data =22%

Intelligent based super capacitor inaccurate Sensor Data=19.3%

%improvement in the reduction of inaccurate Sensor Data causes of poor parametric =

Conventional inaccurate Sensor Data - Intelligent based super capacitor inaccurate Sensor Data

%improvement in the reduction of inaccurate Sensor Data causes of poor parametric =22% -19.3%

%improvement in the reduction of inaccurate Sensor Data causes of poor parametric =2.7%

To find percentage improvement in the reduction of Inadequate Energy Storage Systems causes of poor parametric analysis of transmitted loads in mechanical system with intelligent based super capacitor =

Conventional Inadequate Energy Storage Systems =10%

Intelligent based super capacitor Inadequate Energy Storage Systems = 8.8%

%improvement in the reduction of Inadequate Energy Storage Systems causes of poor parametric =

Conventional Inadequate Energy Storage Systems - Intelligent based super capacitor Inadequate Energy Storage Systems

%improvement in the reduction of Inadequate Energy Storage Systems causes of poor parametric =10% -8.8%

%improvement in the reduction of inaccurate Sensor Data causes of poor parametric =1.2%

3. RESULTS AND DISCUSION

Table 3 comparison of conventional and Intelligent based super capacitor inaccurate Sensor Data that causes poor parametric analysis of transmitted loads in mechanical system

Time (s)	Conventional inaccurate Sensor Data that causes poor parametric analysis of transmitted loads in mechanical system(%)	Intelligent based super capacitor inaccurate Sensor Data that causes poor parametric analysis of transmitted loads in mechanical system(%)
1	22	19.3
2	22	19.3
3	22	19.3
4	22	19.3
10	22	19.3

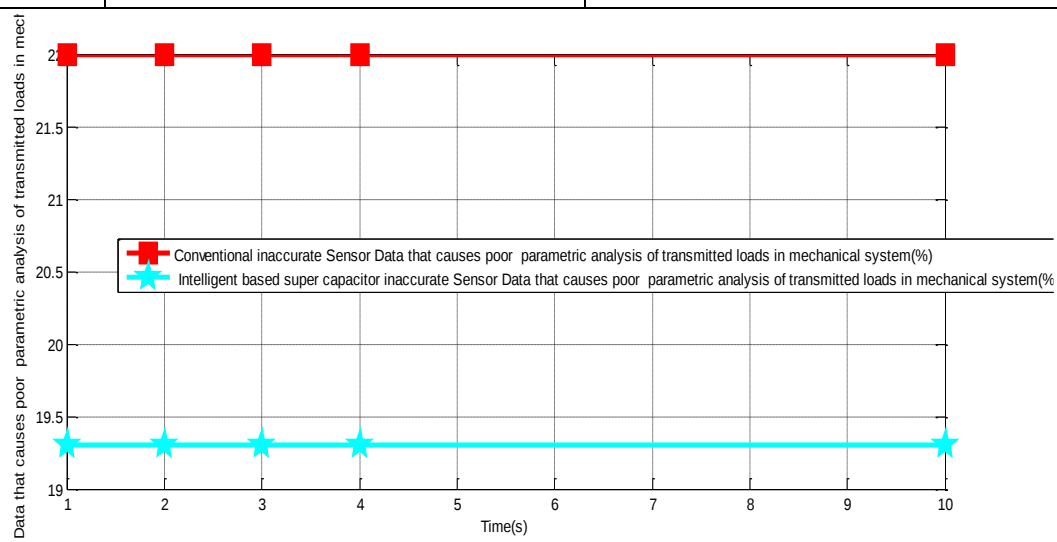


Fig 8 comparison of conventional and Intelligent based super capacitor inaccurate Sensor Data that causes poor parametric analysis of transmitted loads in mechanical system

The conventional inaccurate Sensor Data that causes poor parametric analysis of transmitted loads in mechanical system was 22%. On the other hand, when an Intelligent based super capacitor was integrated in the system, it automatically reduced it to 19.3%.

Table 4 comparison of conventional and Intelligent based super capacitor Inadequate Energy Storage Systems that causes poor parametric analysis of transmitted loads in mechanical system

Time (s)	Conventional Inadequate Energy Storage Systems that causes poor parametric analysis of transmitted loads in mechanical system(%)	Intelligent based super capacitor Inadequate Energy Storage Systems that causes poor parametric analysis of transmitted loads in mechanical system(%)
1	10	8.8
2	10	8.8
3	10	8.8
4	10	8.8
10	10	8.8

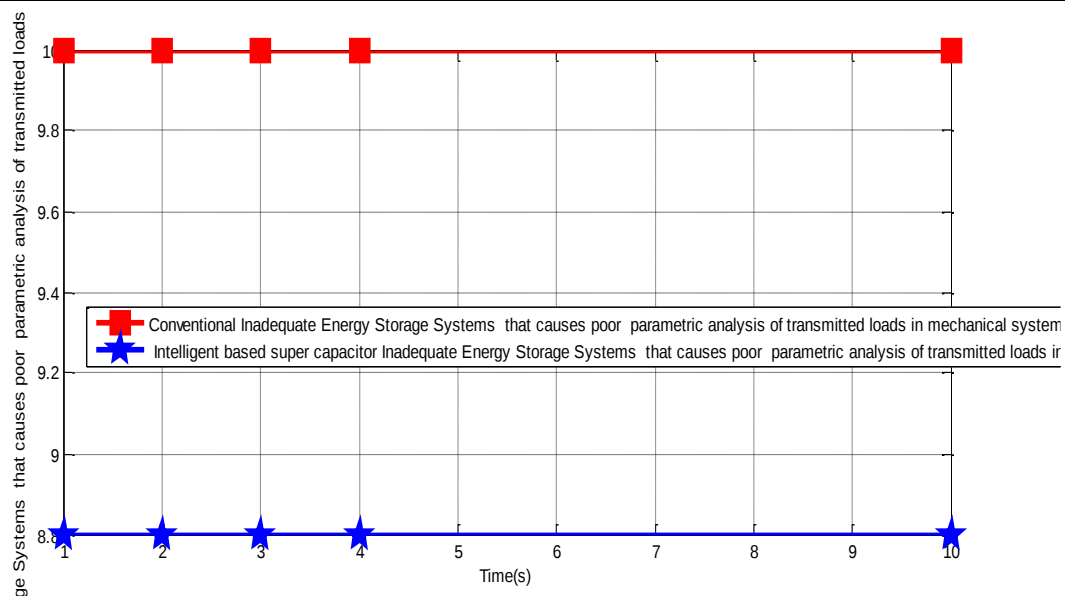


Fig 9 comparison of conventional and intelligent based super capacitor Inadequate Energy Storage Systems that causes poor parametric analysis of transmitted loads in mechanical system

The conventional Inadequate Energy Storage Systems that causes poor parametric analysis of transmitted loads in mechanical system was 10%. Meanwhile, when an intelligent based super capacitor was incorporated in the system, it drastically reduced it to 8.8%. Finally, with these results obtained, the percentage enhancement in parametric analysis of transmitted loads in mechanical system when an intelligent based super capacitor was imbibed in the system was 1,2%

4. CONCLUSION

The integration of intelligent-based supercapacitors for parametric analysis of transmitted loads in mechanical systems presents a significant advancement in load evaluation and energy management. Traditional load analysis methods, which rely on passive damping and conventional capacitors, often fail to provide real-time adaptability and efficient energy utilization. This study has demonstrated that incorporating intelligent control mechanisms, such as fuzzy logic and artificial intelligence, with supercapacitor technology enhances load assessment accuracy, reduces transient fluctuations, and improves overall system stability. The findings highlight the superior performance of intelligent-based supercapacitors in optimizing energy distribution, minimizing mechanical stress, and extending the operational lifespan of mechanical systems. These benefits make the technology highly applicable to industries such as aerospace, automotive, and manufacturing, where precise load transmission analysis is essential for efficiency and reliability. Future research should focus on refining intelligent control algorithms, improving supercapacitor materials, and exploring hybrid energy storage systems to further enhance mechanical system performance. The adoption of intelligent-based supercapacitors paves the way for more adaptive, resilient, and energy-efficient mechanical load

management solutions, ensuring sustainable advancements in engineering applications. The conventional Inadequate Energy Storage Systems that causes poor parametric analysis of transmitted loads in mechanical system was 10%. Meanwhile, when an intelligent based super capacitor was incorporated in the system, it drastically reduced it to 8.8%. Finally, with these results obtained, the percentage enhancement in parametric analysis of transmitted loads in mechanical system when an intelligent based super capacitor was imbibed in the system was 1.2%

5. REFERENCES

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